APPENDIX

Meetings

Summits

NIA Compliance

FHWA: Off-Model Air Quality Analysis – A Compendium of Practice – August 1999

Northwest Regional Summit
March 21, 2000, 8:30 AM
MEETING SUMMARY

Attending:

Name	Agency	Phone
Roy Absher	Wilkes County Board of Commissioners, DCOG, Vice Chairman	(336) 838-5707
Gregory Atchley	NC Emergency Management, Area Coordinator	(704) 878-3309
Wayne Atkins	NCDOT Division 11, Division Operations Engineer	(336) 667-9111
Randy Bennett	North Wilkesboro Police Department, Captain	(336) 838-3158
Larry Bowman	VMS Inc.	(540) 646-2660
Evelyn Byers	Lovette Company	(800) 932-7239
Jimmy Carter	US Aviation	(336) 696-2359
Mike Caudill	Alleghany County, Sheriff	(336) 372-4455
Linda Cheek	Wilkes Chamber of Commerce, Inc., Director	(336) 838-8662
W. G. Dinkins	Yadkin County Board of Commissioners, Chairman	(336) 679-8014
Calvin Dull	Wilkes Community College, Dean of Continuing Education	(336) 838-6208
Vickie Embry	NCDOT, Area Traffic Operations and Safety Engineer	(336) 896-7037
Randy Feimster	North Carolina Department of Motor Vehicles	(704) 878-4249
Pam Fencl	Elkin, Planning Director	
Kenn Fink	Kimley-Horn and Associates	(919) 677-2000
Charles Gantt	Virginia Department of Transportation, Engineer	
Hon. John Garwood	North Carolina, District 27- NC Senator	(919) 733-5651
Junior Goad	Virginia Department of Transportation, Resident Engineer	(540) 728-2813
James Hambright	NCDOT, Traffic Congestion & Engineering Operations	(919) 250-4151
Robert Handy	Wilkes County Board of Commissioners- Chairman	(336) 973-4109
David Hayes	Lovette Company	(800) 932-7239
Elizabeth Honeycutt	NCDOT, Traffic Congestion & Engineering Operations	(919) 250-4151
Grady Hunter	Yadkin County Board of Commissioners, Vice Chairman	(336) 367-7326
Greg Krueger	Kimley-Horn and Associates	(919) 677-2000
Dean Ledbetter	NCDOT Division 11	(336) 667-9111
Gerald Leftwich	Alleghany County, Emergency Coordinator	(336) 372-6220
Ann R. Lorscheider	NCDOT, Traffic Congestion & Engineering Operations	(919) 250-4151
Bryan Maines	Alleghany County, Deputy Sheriff	(336) 372-4455
Chris McDonald	VDOT, Salem District Assistant Traffic Engineer	(504) 387-5393
Hon. Kenneth Moore	North Carolina, District 27- NC Senator	(919) 733-5651
Kenneth Noland	Wilkesboro-Manager	(336) 838-3951
Jo Ann Oerter	NCDOT, Traffic Congestion & Engineering Operations	(919) 250-4151
Steve Palmer	Lowe's Companies, Inc., Director of Transportation	(336) 651-4334
Walter Plexico	Wilkes Community College, Dean of Instruction	(336) 838-6128
Wil Ravenhorst	Kimley-Horn and Associates	(919) 677-2000
Eddie Robinson	VMS Inc., Emergency Response Coordinator	(540) 646-2660
Paul Robinson	Wilkes County, Planning Director	(336) 651-7340
Frank Sells	Surry Community College, President	(336) 386-8121
Captain Jerry Smith	North Carolina State Highway Patrol	(828) 466-5504
Lindburg Swaim	Jonesville, Fire Chief	(336) 366-7576
Steve Triplett	Surry County Schools, Director of Transportation	(336) 386-8211
Dale Trivette	Yadkin County, Director of EMS	(336) 679-4232

Eddie Weatherman	Yadkin County, Fire Marshall	(336) 679-4233
Ronnie Wingler	Lovette Company	(800) 932-7239
Cecil Wood	Yadkin County, Manager	(336) 679-4200
Charles Wooten	Wilkes School Systems, Transportation Director	(336) 667-1126

The ITS Strategic Deployment Plan– Northwest Regional Summit commenced at approximately 8:30 AM at The Inn at Wilkesboro in Wilkesboro, North Carolina. Following is a summary of the proceedings of this meeting.

8:30-9:30 AM Guests were registered and given the opportunity to explore demonstrations that were given on ITS technologies. Included was a demonstration of NCDOT's ncsmartlink.org traffic information web page; a presentation of web pages across the nation showing real-time traffic information, and a video demonstrating ITS applications. Coffee was available during this time.

9:30-9:40 Mr. Wayne Atkins, P.E., Division Operations Engineer for the North Carolina Department of Transportation, welcomed everyone and provided a brief introduction and overview of the summit meeting.

9:40-10:20 Mr. Kenn Fink, P.E., and Mr. Greg Krueger, P.E., presented an overview of ITS that included specific technologies as well as their benefits.

10:20-10:40 Mr. Dean Ledbetter, P.E., Division Traffic Engineer for the North Carolina Department of Transportation, spoke on the existing ITS the Northwest Region and the proposed ITS that was soon to be implemented in the northwest region.

10:40-11:15 A discussion group was conducted by Mr. Kenn Fink, P.E., and Ms. Ann Lorscheider, P.E. A summary of the discussion group is below.

DISSCUSSION GROUP FINDINGS

Issues:

- Permanent signs needed (Variable Message Signs- VMS)
- Need information on construction and weather events
- US 421 out of Wilkesboro is congested and could use help
- Ski/Tourist season adds to congestion
- Through traffic unaware of problems- notify drivers at US 421/I-77
- Need to communicate to fleet operators
- Get information from Highway Patrol and disseminate that information to others
- Need regional/multi-state incident planning, response and information

- Know conditions on alternate route and update
  - Detouring traffic can cause more issues
- Provide traveler information in-vehicle, and via email and beeper
- Need to link www.ncsmartlink.org to other states
  - (example: www.vdot.state.va.us)
  - Communication with Virginia over the mountains
- Kiosks would be helpful
  - Located at rest areas, resorts, hotels and Super K, etc.
- Provide weather information on I-77
- Communication between snow plows, enforcement, etc.
- Exit 282 (off US 421) experiences congestion from school drop-off
- Auto-email would be useful to commercial vehicles operations providers, etc.
- Free passage for commercial vehicle operations
- Inform DOT, DMV and SHP of information put on traveler information system
- Higher frequency for Highway Advisory Radio

11:15-11:30 Ms. Ann Lorscheider, P.E., Traffic Operations Engineer for the North Carolina Department of Transportation ended the summits by thanking everyone for attending and encouraging them to continue to play and active role in the ITS development within the region.

ACTION ITEM (S):

We would like your input on these minutes, as well as your input on the Summit in general. We will be holding more meetings across the state and would like to know your opinions of what was good, and what could be improved. You will receive mailings if additional meetings are scheduled in this area

Please direct any comments or suggestions you have for these minutes, the Summit, or additional technological solutions and barriers in this region on enclosed survey or to Kenn Fink via email at its-Mountains@kimley-horn.com or by phone at (919) 677-2237.

Thank you for your input and support and your attendance.

Boone Regional Summit
March 22, 2000, 8:30 AM
MEETING SUMMARY

Attending:

Name	Agency	Phone
Millie Barbee	North Carolina High Country Host, Inc.	(828) 264-1299
Roy Barthel	Window Views Bed and Breakfast	(828) 963-8081
Francis Borkowski	Appalachian State University Foundation, Inc., Chancellor	(828) 262-2040
Phill Bratt	IRC Inc.	(828) 264-8861
William Bullock	North Carolina State Highway Patrol, Troop Lieutenant	(828) 466-5504
Bill Burleson	Banner Elk, Chief of Police	(828) 898-4300
Velma Burnley	Boone, DCOG, Mayor	(828) 262-4530
Judy Donaghy	Avery/Banner Elk Chamber of Commerce	(828) 898-5605
Vickie Embry	NCDOT (Area 4), Asst. Area Traffic Engineer	(336) 896-7037
Lt. Featherstone	North Carolina Department of Motor Vehicles, Enforcement	(704) 466-5511
Kenn Fink	Kimley-Horn and Associates	(919) 677-2000
Honorable Virginia Foxx	North Carolina, District 12- NC Senator	(919) 733-5651
Joseph Furman	Watauga County, Planning and Inspection Director	(828) 265-8043
Deron Geouqure	Village of Sugar Mountain, Village Manager	(828) 898-9292
James Hambright	NCDOT, Traffic Congestion & Engineering Operations	(919) 250-4151
Reginald Hassler	Boone, Fire Chief	(828) 262-4520
Wayne Herron	Boone, Director of Planning	(828) 262-4530
Don Holycross	Blowing Rock, Town Manager	(828) 295-5200
Elizabeth Honeycutt	NCDOT, Traffic Congestion & Engineering Operations	(919) 250-4151
Terry Hopkins	NCDOT, Traffic Congestion & Engineering Operations	(919) 250-4151
Bob Kennedy	Boone, Assistant Chief of Police	(828) 262-4500
Greg Krueger	Kimley-Horn and Associates	(919) 677-2000
Kathryn Lawrence	Ashe County Chamber of Commerce, Director	(336) 246-9550
Laureette Leagon	Boone Area Chamber of Commerce	(828) 264-2225
Dean Ledbetter	NCDOT Division 11, Division Traffic Engineer	(336) 667-9111
Ann R. Lorscheider	NCDOT, Traffic Congestion & Engineering Operations	(919) 250-4151
James Lyons	Watauga County, Sheriff	(828) 264-3761
Carl McCann	NCDOT Division 11, Division Engineer	(336) 667-9111
Jerry Moretz	Watauga Medical Center	(828) 262-4391
Robert Nelson	Watauga County, County Manager	(828) 265-8000
Jo Ann Oerter	NCDOT, Traffic Congestion & Engineering Operations	(919) 250-4151
Bill Post	Boone, Chief of Police	(828) 262-4500
Wil Ravenhorst	Kimley-Horn and Associates	(919) 677-2000
Larry Rhodes	Ashe County Board of Commissioners	(336) 246-9047
Larry Roten	Lansing, Fire Chief	(336) 384-3456
Jeff Simms	Watauga Democrat	(828) 264-3659
Marion Sofield	Boone Area Chamber of Commerce	(828) 264-3082
Jim Thompson	Mountain Times, Senior Editor	(828) 264-6397
Phillip Trew	DCOG, Regional Planner	(828) 265-5434
Chris Turner	AppalCART	(828) 264-2278
Michael Wagoner	Boone Area Chamber of Commerce, President	(828) 262-3516

Boone Regional Summit
March 22, 2000, 8:30 AM
MEETING SUMMARY

The ITS Strategic Deployment Plan– Boone Regional Summit commenced at approximately 8:30 AM at The Broyhill Inn in Boone, North Carolina. Following is a summary of the proceedings of this meeting.

8:30-9:30 AM	Guests were registered and given the opportunity to explore demonstrations that were given on ITS technologies. Included was a demonstration of NCDOT's ncsmartlink.org traffic information web page; a presentation of web pages across the nation showing real-time traffic information, and a video demonstrating ITS applications. Coffee was available during this time.
9:30-9:40	Mr. Carl McCann, P.E., Division Engineer for the North Carolina Department of Transportation, welcomed everyone and provided a brief introduction and overview of the summit meeting.
9:40-10:20	Mr. Kenn Fink, P.E., and Mr. Greg Krueger, P.E., presented an overview of ITS that included specific technologies as well as their benefits.
10:20-10:40	Ms. Millie Barbee, Director of the North Carolina High County Host spoke on the tourism and its influence on the economy, traffic and lifestyle in the Boone region Mr. Dean Ledbetter, P.E., Division Traffic Engineer for the North Carolina Department of Transportation, spoke on the existing ITS in the northwest region and the proposed ITS that was soon to be implemented in the northwest region.
10:40-11:15	A discussion group was conducted by Mr. Kenn Fink, P.E. and Ms. Ann Lorscheider, P.E. A Summary of the discussion group is shown below.

DISSCUSSION GROUP FINDINGS

Issues:

- Improvements to signals (ex. High School Drive)
- High school traffic (middle lane straight/left)
- Turn lane needed at the bridge (would require widening of the bridge)
- Emissions are becoming an issue
- Signal system needed on US 321
- Pedestrian access needed to high school at NC 105
- Bike lanes on US 421, etc.
- Need better reports on accurate road conditions
- King Street is heavily congestion downtown

- Need accurate weather reports
  - Fog detection systems
- Central telephone number needed for traffic information
- Link local websites to www.ncsmartlink.org
  - Regionalize traveler information
  - Transit information/Amtrak on ncsmartlink.org
- Traffic Hot spots
  - US 421 and SR 105 interchange when US 421 4-lane is finished
  - Highway SR 105 Rock Crusher/ Avery Co. Line (accidents, icing, dangerous curves)
  - Highway US 421 West
  - SR 105/US 421 Bypass interchange
  - Traffic out of apartments onto SR 105 Bypass
- Better coordination needs to occur that road construction does not occur during special events
- Intersection improvements need to be made at most intersectionsin town
- Signalization for several intersections should be evaluated
- Tourism (information) needs to be provided as part of traveler information
- Kiosks at major public areas
  - Shops on Parkway
  - Mall
  - Grandfather Mountain
  - Ski Resorts
  - Student Union
  - Visitor Center
  - US 421 Deep Gap
- Emergency Information to motorist and tourist who may be traveling to the area
- NCDOT needs to provide more information to chambers of commerce on construction and maintenance activities in the area
- Auto email/fax would be useful
- Bridge at Deep Gap a problem with safety and congestion
- Better signage needed for entry and exit location on parkway

11:15-11:30 Ms. Ann Lorscheider, P.E., Traffic Operations Engineer for the North Carolina Department of Transportation, ended the summits by thanking everyone for attending and encouraging them to continue to play and active role in the ITS development within the region.

ACTION ITEM (S):

We would like your input on these minutes, as well as your input on the Summit in general. We will be holding more meetings across the state and would like to know your opinions of what was good, and what could be improved. You will receive mailings if additional meetings are scheduled in this area

Please direct any comments or suggestions you have for these minutes, the Summit, or additional technological solutions and barriers in this region on enclosed survey or to Kenn Fink via email at its-Mountains@kimley-horn.com or by phone at (919) 677-2237.

Thank you for your input and support and your attendance.

Sylva Regional Summit
March 23, 2000, 8:30 AM
MEETING SUMMARY

Attending:

Name	Agency	Phone
Ted Adams	NCDOT Division 14, Resident Engineer	(828) 586-2141
Lt. J. Austin	North Carolina Department of Motor Vehicles, Enforcement	(828) 251-6081
Keith Brazell	NCDOT Division 14, Resident Engineer	(828) 586-2141
Linda Cable	Swain County, Administrator	(828) 488-9273
Larry Callicutt	Bryson City, Manager	(828) 488-3335
Tamera Crisp	Jackson County, Planning Department	(828) 586-7575
Susan Cutshaw	Swain County Chamber of Commerce	(828) 488-3681
Larry Dehart	NCDOT Division 14, Division Operations Engineer	(828) 586-2141
Mike Ensley	Jackson County Emergency Management, Director	(828) 586-7592
Kenn Fink	Kimley-Horn and Associates	(919) 677-2000
Phil Francis	Great Smokey Mountains National Park	(423) 436-1200
D. (Bucky) Galloway	NCDOT, Area Traffic Engineer	(828) 251-6178
Ed Green	NCDOT Division 14, District 1 Engineer	(828) 586-2141
Teddy Greene	NCDOT, Division Right of Way	(828) 386-4040
Cecil Groves	Southwester Community College, President	(828) 586-4091
William Guillet	Canton, Chief of Police	(828) 648-2376
Hon. R. Phillip Haire	North Carolina, District 52- NC Representative	(828) 631-3124
Wanda Hall	Jackson County Emergency Mgmt., 911 Coordinator	(828) 586-7592
James Hambright	NCDOT, Traffic and Congestion Engineering Operations	(919) 250-4151
Linda Harbuck	Franklin Chamber of Commerce	(828) 524-3161
Elizabeth Honeycutt	NCDOT, Traffic Congestion and Engineering Operations	(919) 250-4151
Terry Hopkins	NCDOT, Traffic Congestion and Engineering Operations	(919) 250-4151
M. James	NCSHP, Troop "G" Headquarters	(828) 298-4253
Jeff Jamison	Sylva, Chief of Police	(828) 586-2719
David Jones	Tri-County Community College	(828) 837-6810
Greg Krueger	Kimley-Horn and Associates	(919) 677-2000
F. Martin	NCDOT Division 14, Division Engineer	(828) 586-2141
Gene McAbee	Western Carolina University	(828) 227-7301
Steve Meyer	David Volkert & Associates	(423) 842-3335
Reuben Moore	NCDOT Division 14, Division Traffic Engineer	(828) 586-2141
Toby Moore	West Care EMS	(828) 586-7608
Dale Nations	Sylva Fire Department	(828) 586-2218
Jo Ann Oerter	NCDOT, Traffic Congestion and Engineering Operations	(919) 250-4151
Brenda Oliver	Sylva, Mayor	(828) 586-2719
Johnson Owle	Eastern Band of the Cherokee, Transportation Planner	(828) 497-2771
Kenneth Putnam	NCDOT Division 13, Division Operations Engineer	(828) 251-6171
Wil Ravenhorst	Kimley-Horn and Associates	(919) 677-2000
Forest Ray	Jackson County Chamber of Commerce	(800) 962-1911
David Redman	Cherokee Tribal Travel and Promotions	(828) 497-9195
Ron Ruehl	NC Dept. of Commerce, Division of Tourism	(828) 277-7096
Glenda Sansosti	City of Brevard	(828) 884-4080

Richard Schaddelee	Swain County Chamber of Commerce	(828) 488-3681
Joel Setzer	NCDOT Division 14, District 3 Engineer	(828) 586-2141
Greg Shuler	NCDOT, Design Engineer	(828) 586-2141
David Slagle	Tri-County Community College	(828) 837-6810
Terry Slaughter	Graham County Emergency Management, Director	(828) 479-7967
Jay Spiro	Sylva Partners in Renewal	(828) 586-2466
Julie Spiro	Jackson County Chamber of Commerce	(800) 962-1911
Jay Swain	NCDOT Division 14, Division Maintenance Engineer	(828) 586-2141
Russell Teague	Canton, Fire Chief	(828) 646-3418
J. Teague	NCDOT Division 14, Asst. Division Traffic Engineer	(828) 586-2141
Ron Watson	NCDOT Division 14, Division Construction Engineer	(828) 586-2141
Don Weaver	Clay County Emergency Management	(828) 389-6354
Paul White	NCDOT, Assistant Resident Engineer	(828) 497-7333
Dennis Wilde	Brevard, Chief of Police	(828) 883-2212
Jonathan Woodard	NCDOT, Assistant District Engineer- District 2	(828) 488-2131

The ITS Strategic Deployment Plan- Sylva Regional Summit commenced at approximately 8:30 AM at Western Carolina University in Cullowhee, North Carolina. Following is a summary of the proceedings of this meeting.

8:30-9:30 AM Guests were registered and given the opportunity to explore demonstrations that were given on ITS technologies. Included was a demonstration of NCDOT's ncsmartlink.org traffic information web page; a presentation of web pages across the nation showing real-time traffic information, and a video demonstrating ITS applications. Coffee was available during this time.

9:30-9:40 Mr. Dan Martin, P.E., and Division Engineer for the North Carolina Department of Transportation welcomed everyone and provided a brief introduction and overview of the summit meeting.

9:40-10:15 Mr. Kenn Fink, P.E., and Mr. Greg Krueger, P.E., presented an overview of ITS that included specific technologies as well as their benefits.

10:15-10:20 The Honorable R. Phillip Haire, North Carolina Representative for District 52, provided insight into the state of transportation in North Carolina and in the region.

Sylva Regional Summit
March 23, 2000, 8:30 AM
MEETING SUMMARY

10:20-10:40 Mr. Ron Ruehl, Heritage Tourism Development officer for NC Travel and Tourism, discussed the history of tourism now and in the future to the area. Mr. Reuben Moore, P.E., Division 14 Traffic Engineer for the North Carolina Department of Transportation and Mr. Ken Putnam, P.E., Division 13 Traffic Engineer for the North Carolina Department of Transportation spoke about the existing ITS deployments in the area and how those systems were currently being used. An example of how ITS was used during the I-40 rock slide was also discussed.

10:40-11:15 Breakout sessions were conducted with two groups, each one focusing on a specific topic. Groups were asked to answer/discuss a series of questions on the topics of Traffic/Incident Management and Traveler Information Systems. Summaries from the breakout groups are shown below.

BREAK-OUT GROUP FINDINGS

TRAFFIC MANAGEMENT and INCIDENT MANAGEMENT

- Western North Carolina University's population is 6,000-10,000 students (based on the time of the day)
    - Pedestrian accidents rate is high
    - Lack of public transportation (especially for exchange students)
    - Safety is a concern for Emergency Services on two-lane rural windy roads
        - Dangerous situations
        - Getting emergency services in and out safely
        - Lack of good detour routes
- NC 107 (Intersection with US 23)
    - Second highest traveled roadway
    - Trucks; high speed; equipment failures causing accidents
- Truck rollover and accidents areas
    - Bryson City
    - US 23/74 at Balsam
- Cherokee Area
    - US 441 needs road construction information
    - Highway Advisory Radio needed
    - Websites needed to give travelers and tourist information
- Use flasher "Tune To" signs to reach motorist

- Weather Information to motorist
  - Website based information system needed
  - Need way to get information to motorist
  - "1-800' number
  - Changeable message signs needed
  - Link with local television (channel 13) Asheville
    - Cable access- very localized
- Bryson City
  - Signal coordination (especially at tourist season)
  - Standards for reportable accidents (Brevard)
    - Minimum reportable damage estimates $1,000 or more (there is a paper work issue)
    - Missing accidents accidents in final data
- Traffice Crash Data
  - Timely Reporting and recording
  - Conflict analysis (near misses) relates directly to accident rates
  - Quick need for response team
    - Detour routes decided on, before incident occurs
    - Need incident management plans
  - Truck traffic through Canton
  - ITS needs local level input into TIP
    - Signal systems needed
    - "Machine Vision" technology for detection
  - Educate local officials on benefits of ITS
    - Competition for dollars

TRAVELER INFORMATION SYSTEMS

- Information on all road conditions needed
- Lack of/better signage to inns and bed and breakfasts, tourist spots (utilize symbols)
- Include signs in unincorporated areas
- Numbering red lights to aid in directions
- Speed limit and pedestrian warnings marked on pavement
- Hash crosswalks
- Consistent signing (statewide and nationwide)
- Need to review signs on the roadway to ensure that they are needed
- Real-time Information (reliable)
- Heavy RV traffic can be a problem because of their widths

- Potential kiosks locations:
    - Smokey Mountain West Visitor Center
    - Visitor Centers
    - Cherokee Visitor Center
    - Jackson Co. Visitor Center
    - Franklin Co. Visitor Center
    - National Parks
    - Murphy (US 64)
- Link from NCSMARTLINK.ORG to MAPQUEST.COM
- Provide information to trucking industry on approved commercial vehicle routes
- Variable message signs on Interstate roads
    - Smaller variable message signs on shoulder mounts
- Highway Advisory Radio's traveler information and tourist information (better use of ones we have and add new ones)
- Congestion problems on SR 107
    - From business 23 out to Western Carolina University
    - Within surrounding area of Cashiers
- Better interagency coordination/communication needed
- Connect NCSMARTLINK.ORG with parks service
- Spend money on highway advisory radio's vs. variable message signs to distribute information

ACTION ITEM (S):

We would like your input on these minutes, as well as your input on the Summit in general. We will be holding more meetings across the state and would like to know your opinions of what was good, and what could be improved. You will receive mailings if additional meetings are scheduled in this area

Please direct any comments or suggestions you have for these minutes, the Summit, or additional technological solutions and barriers in this region on enclosed survey or to Kenn Fink via email at its-Mountains@kimley-horn.com or by phone at (919) 677-2237.

Thank you for your input and support and your attendance.

National ITS Architecture Compliance

The Statewide ITS Architecture and Strategic ITS Deployment Plan development process are both intended to be planning tools. The Strategic ITS Deployment Plan is a planning document that draws inputs from potential ITS customers throughout the State and Region. These inputs are logged and documented, then ranked to provide a snapshot of the perceived ITS needs for the next 20 years. Based on this documentation, the benefits of each project or improvement can be identified and, in turn, added to regional Transportation Improvement Plans (TIP) and the North Carolina Statewide Transportation Improvement Plan (STIP).

The development of the Statewide ITS Architecture is intended to guide the implementation process by providing a structure around which to design. ITS elements and concepts are generically named to permit a wide variety of design options, changes in technology, or institutional changes that occur over time. The intent is to provide freedom to designers and implementers by providing a stable structure for interconnection while providing flexibility to meet the unique needs of specific users.

The National ITS Architecture is divided into three levels: logical, physical and technical. The logical architecture provides a functional view of a system that assists in organizing complex entities and relationships by identifying system functions and information flows. The logical architecture guides development and deployment through functional requirements that are independent of institutions and technology. The logical architecture does not identify how each ITS function is to be implemented.

The physical architecture is the physical representation of how a system should provide the desired functionality. The physical architecture defines the information and data flows between elements and the communication requirements needed to make the system function. The data flow definitions within the physical architecture require standards to provide functionality between systems, which is the basis of the ITS standards development process.

The technical architecture is the formal design and implementation process. The technical architecture defines the implementation of the physical architecture. The technical architecture is the formal design and implementation that defines system hardware and software functionality, their interaction, and the deployment of a system that processes and distributes the gathered data.

The three levels of the National ITS Architecture work together to refine the ITS needs from the planning stage down to a specific hardware deployment. For example, the logical and physical architecture may identify the need for shared traffic information. The physical architecture would define traffic information as traffic data from detectors and video from CCTV cameras.

The purpose of this document is to develop a logical architecture for ITS deployments in the State of North Carolina. The physical architecture is part of this document, but only in describing the interaction between elements, centers, etc. The appendices document the physical architecture through the data flow diagrams and other visual methods.

This document provides the logical and physical architectures as required by FHWA and used in the long-term ITS deployment throughout the state. The details in the development of the technical architecture are left up to each entity and their designers and implementers. The logical and physical architecture layers are a tool that is to be used by the designers and implementers to ensure that data and information is shared between systems. By approaching the ITS Architecture deployment from the logical and physical levels, this document will serve as a roadmap for ITS deployments throughout the State of North Carolina for years to come without locking the State into specific technologies that may change over time.

Off-Model Air Quality Analysis: A Compendium of Practice

Federal Highway Administration
Southern Resource Center
August 1999

Introduction

Air Quality analysis methodologies have become more refined over the years to fill the need in the transportation community to satisfy various requirements including Transportation Conformity and Congestion Mitigation and Air Quality Program project justification. Off-Model methods continue to be developed and refined to allow for analysis of innovative, as well as some common, projects to account for reductions in vehicular emissions. The most typical analysis is associated with Vehicle Miles of Travel (VMT) reductions, but reductions in emissions can also occur due to decreases in vehicular delay.

This is an observation in techniques which have been used in the South to provide for the evaluation of possible emission reductions. For the purpose of this compendium, Off-Model methodologies are analyses performed without the specific use of a Travel Demand Model. As previously stated, these analyses can be used for either of two primary purposes. These two purposes are Transportation Conformity Analyses and Congestion Mitigation and Air Quality (CMAQ) Improvement Program project justifications. The later of these two is probably the most crucial given the need for project justification as a funding mechanism; however, with the increasing difficulties in showing an offset of VMT growth in most areas, any reduction will only provide a benefit to the Conformity Process.

This compendium offers a look into several methodologies utilized in Federal Highway Administration's Southern Resource Center geographic area and may be duplicated and disseminated at will. These methodologies are not all encompassing but should offer valuable insight into Off-Model practice. Updates of this compendium will occur and include any needed changes in the reference section.

If you have any questions or comments please address them to:

Andrew Edwards, Air Quality Specialist
Federal Highway Administration
Southern Resource Center
61 Forsyth St., Suite 17T26
Atlanta, GA 30303-3104
(404) 562-3673

Table of Contents

Intersection Improvements

1. General Analysis[1]

This analysis incorporates a conservative approach to intersection improvements. It can be used for grade separation and signal timing. The conservative approach is only analyzing Volatile Organic Compound (VOC) reductions; however, NO_x may be analyzed in a similar fashion.

The analysis is as follows:

a) Calculate the existing VOC emissions.
$VOC_B = EF_B * VOL_{APP} * DIST_{APP}$

where,
VOC_B = Emissions before improvement, grams
EF_B = Emission factor (grams per mile) based on assumed speed before improvement
VOL_{APP} = Peak period approach volume
$DIST_{APP}$ = Approach distance in miles

b) Determine the average speed after the improvement.

c) Calculate the VOC emissions after the improvement.
$VOC_A = EF_A * VOL_{APP} * DIST_{APP}$

where,
VOC_A = Emissions after improvement, grams
EF_A = Emission factor (grams per mile) based on average speed after improvement

d) Calculate daily VOC emission reductions.
$VOC_R = (VOC_B - VOC_A)$

where,
VOC_R = VOC emission reductions, grams/day

2. Traffic Signal Computer Upgrade[2]

The analysis of this project was for the upgrade of computer equipment and software, cabinets and controllers, and replacement of the Communications Plant. The justification was based on an increase in the reliability of the traffic control device synchronization in the metropolitan area. This would decrease delays and reduce vehicle idle emissions. The analysis for this project was performed as follows:

a) 3-4 minutes per vehicle per direction on a major arterial with an average vehicle rate of 38,000 vehicles or 2533 hours per day was assumed to be the savings by having the more reliable system. These are the savings for a single computer section.

b) There were 60 computer sections amounting to a savings in idle time of 152,000 hours of vehicle delay per day.

c) Emission rates were established by Hillsborough County using Mobile 5a. The rates were as follows:
CO = 0.32018 kg/vehicle hour
VOC = 0.0227 kg/vehicle hour
NO_x = 0.00988 kg/vehicle hour

d) To be conservative, especially with the negative benefits which would occur for NOx with an increase in speed, emission benefits were assumed to occur only during the AM and PM peak periods (4 hours total).

e) The benefits were then calculated.
CO = (0.32018 kg/vehicle hour)(152,000 veh hrs/day)(4 pk hrs/24 hrs) = 8,111 kg/day (8.922 tons/day)

VOC = (0.0227 kg/vehicle hour)(152,000 veh hrs/day)(4 pk hrs/24 hrs) = 575 kg/day (0.632 tons/day)

NO_x = (0.00988 kg/vehicle hour)(152,000 veh hrs/day)(4 pk hrs/24 hrs) = 250 kg/day (0.275 tons/day)

Note: Delay reductions can be obtained through most intersection analysis software.

High Occupancy Vehicle (HOV) Lanes

1. General Analysis

Similar to the general intersection analysis, the HOV lane analysis is again conservative with only VOC reductions accounted; however, NO_x may be analyzed in a similar fashion. This analysis also assumes that emission reductions are for the HOV lane only.

The analysis is performed as follows:

a) Calculate the existing VOC emissions.
$VOC_B = EF_B * VOL_B * DIST$

where,
VOC_B = Emissions before improvement, grams
EF_B = Emission factor (grams per mile) based on assumed speed before improvement
VOL_B = HOV Volume * Auto Occupancy of HOV / AO of Mixed Flow
DIST = HOV lane distance in miles

b) Determine the average speed after the improvement.

c) Calculate the VOC emissions after the improvement.
$VOC_A = EF_A * VOL_A * DIST$

where,
VOC_A = Emissions after improvement, grams
EF_A = Emission factor (grams per mile) based on average speed after improvement
VOL_A = HOV Volume after improvement

d) Calculate daily VOC emission reductions.
$VOC_R = (VOC_B - VOC_A)$

where,
VOC_R = VOC emission reductions, grams/day

Transit Improvements

1. General Analysis[1]

The key to Transit Improvements is increased ridership. If transit ridership goes up then Vehicle Miles of Travel (VMT) should be reduced proportionately. The approach to this analysis is trend, that is, the analysis should call on previous expansions and their effect on ridership as input into the analysis. Since this increased ridership actually decreases VMT, reductions are found for both VOCs and NO_x.

The analysis is as follows:

a) Calculate the daily VMT reduction.
VMT = (Avg. Daily Ridership After - Avg. Daily Ridership Before) / Avg. Auto Occupancy * Avg. Trip Length

b) Calculate the reduction in daily emissions.
$E_D = EF_x * VMT$

where,
E_D = Daily Emissions, grams/day
EF_x = Emission factor for pollutant x, grams/mile
VMT = vehicle mile/day

2. Express Bus Service for Broward County, Florida[3]

The analysis of this project was done to add new Express Bus Service in Broward County Florida. The basis for the project was to provide a needed service to the general public and reduce Vehicle Miles of Travel (VMT). The new transit service will operate during the morning (AM) and afternoon (PM) peaks. The AM peak will consist of three one-way trips from southwest Broward County to Downtown Fort Lauderdale with one return trip. The PM peak will consist of the reversal of the AM peak. Each peak is considered for exactly two hours (6:00AM to 8:00AM and 4:00PM to 6:00PM). The analysis for the project is as follows:

a) The Peak Hour Ridership was determined by running the FSUTMS model (Florida's Travel Demand Model). Both the AM and PM peak ridership were calculated by multiplying the peak hour ridership by 2.0 hours to yield Person Trips.
Peak Hour Ridership (from FSUTMS) = 54 Person Trips
AM Peak = 2.0 Hours * 54 = 108 Person Trips
PM Peak = 2.0 Hours * 54 = 108 Person Trips
Daily Person Trips = 108 + 108 = 216 Person Trips

b) An estimate of auto trips is found by dividing the person trips by the average auto occupancy for Home Based Work (HBW) trips.

216 Person Trips / 1.12 = 193 Auto Trips

c) An estimate of VMT is then calculated by assuming the auto trips would have taken the same trip length as the new service or 31.0 miles.
193 Auto Trips * 31.0 Miles/Trips = 5983 Daily VMT

d) The daily reduction in NO_x and VOC is found from MOBILE 5.0a using Light Duty Gas Vehicle (LDGV) emission rates. The average speed is derived from the average auto travel speed along the proposed transit route, which is 37.9 mph.
NO_x emission reduction = 5983 VMT * 1.63 g/mile * kg / 1000 g = 9.75 kg/day

VOC emission reduction = 5983 VMT * 1.25 g/mile * kg / 1000 g = 7.48 kg/day

e) The increase in VMT due to the express service is then found with the knowledge that there are four trips per peak period, again, with a distance of 31.0 miles.
Daily Transit VMT Increase = 31.0 * 8 trips/day = 248 Daily VMT

f) The daily increase in NO_x and VOC is found from MOBILE 5.0a using Heavy Duty Diesel Vehicles (HDDV) emission rates. The average speed is derived from the average bus speed along the proposed route, which is 28.7 mph.
NO_x emission increase = 248 VMT * 1.8 g/mile * kg/1000g = 0.45. kg/day
VOC emission increase = 248 VMT * 11.68 g/mile * kg/1000g = 2.90 kg/day

g) The net reduction is then found.
NO_x emission reduction = [9.75 - 2.90] kg/day = 6.85 kg/day
VOC emission reduction = [7.48 - 0.45] kg/day = 7.03 kg/day

3. <u>Transit Centers</u>[1]

Transit centers combine frequent bus service with park and ride (P&R) lots. The main benefit of these facilities is to reduce VMT, thus allowing for a reduction in both ozone precursors. The analysis for these facilities/projects is as follows:

a) The first step in the analysis is to estimate the number of autos removed by the new facility.
Autos Removed = Historical P&R Lot Utilization * Parking Spaces in Lot

b) Next, knowing the average peak hour speed and the average driving distance for the area emission reductions can be found. Note: Distance is multiplied by 2 to account for round trip.
Auto Emission Reduction = Autos Removed * (Avg. Driving Distance * 2) *Peak Hour Speed Emission Rate for LDGVs

c) Calculate the emissions from the increase in transit vehicles, utilizing known Avg. Driving Distance and Avg. Peak Hour Speed.
Bus Emission Increase = # of Bus Increase * (Avg. Driving Distance * 2) *Peak Hour Speed Emission Rate for HDDVs

d) The final calculation yields emission reductions in kg/day.
Daily Emission Reductions = (Auto Reductions - Bus Increase) * kg/1000g

4. Park and Ride Lots[1]

The P&R lot analysis is similar to the analysis of the transit center with the exception that increased bus service is not added. The analysis is as follows:

a) The first step in the analysis is to estimate the number of autos removed by the new facility.
Autos Removed = Historical P&R Lot Utilization * Parking Spaces in Lot

b) Next, knowing the average peak hour speed and the average driving distance for the area the total emission reductions can be found in, kg/day.
Auto Emission Reduction = Autos Removed * (Avg. Driving Distance * 2) *Peak Hour Speed Emission Rate for LDGVs * kg/1000g

Note: Distance is multiplied by 2 to account for round trip.

5. Alternative Fuel Buses[14]

Broward County, FL proposed to buy 4 alternative fuel (electric) transit buses to operate as circulators in Downtown Ft. Lauderdale. The purpose of this analysis is to demonstrate that using electric buses instead of the heavy-duty diesel buses will improve air quality.

Assumptions

- Buses will operate weekdays between 7:30 am and 5:30 pm (10 hours)
- 30 minute (0.5 hour) headway between buses per route
- Number of Daily Trips = Operation/Headway = 10 hours/0.5 hours = 20 Trips
- Average bus running speed is 14.4 mph
- Electric buses were assumed to produce zero emissions
- MOBILE model was used to obtain HDDV emission rates
- Round Trip distance is approximately 4.8 miles.

Analysis

a) Estimate emissions due to operating 4 diesel buses.

Emissions = Number of Buses * Round Trip Length * Number of Daily Trips * Emission Factor

VOCs = 4 buses * 4.8 round trip miles * 20 trips/day * 0.0030 kg/mile = 1.15 kg/day
CO = 4 buses * 4.8 round trip miles * 20 trips/day * 0.0163 kg/mile = 6.26 kg/day
NOx = 4 buses * 4.8 round trip miles * 20 trips/day * 0.0149 kg/mile = 5.72 kg/day

b) The above values reflect the emissions that would be reduced by replacement of the diesel buses with alternatively fueled buses thus showing an improvement in air quality.

6. Tampa Historic Electric Streetcar[15]

The proposed historic street car, when completed, provides intermodel connections for persons who arrive at the Convention Center or one of the hotels from Tampa International Airport and who have taken a taxi to downtown. To calculate emission benefits the following methodology was used.

a) Ridership projections were obtained from annual attendance figures estimated by the City of Tampa, Ybor City, the Port Authority, the Tampa Bay Lightning, the Florida Aquarium, and the Tampa Convention Center. Ridership figures were also based on the Memphis, TN streetcar project. The Memphis project is given reference since the attractions along the system are more relative to that of the Tampa/Ybor area. Based on the Memphis project a conservative 5% ridership at each of these venues was used for calculations. To estimate the miles saved an assumption was made that half of the estimated 5% ridership would ride the streetcar the 4.5 mile round trip between Ybor City and the Garrison Seaport District and the other half would ride shorter 2 mile trips.

	Yearly Projected Attendance	5% Ridership Assumption
Arena (Tampa Bay Lightning)	800,000	40,000
Aquarium	1,000,000	50,000
Crosstown-Ybor	1,320,000	66,000
Cruise Ships	300,000	15,000
Hogan Burke Theater	1,000,000	50,000
Hotels-Convention Center		
Convention Center	112,000	5,600
Special Events	305,000	15,250
Hyatt Regency	201,000	10,050
Local Events		
Guavaween	75,000	3,750
St. Patricks/Jose Riley	4,000	200
Gasparilla	100,000	5,000
Special Weekend	75,000	3,750
Total		264,600

b) Calculate VMT reductions.
132,300 passengers travel 2.0 miles round trip = 264,600
132,300 passengers travel 4.5 miles round trip = 595,350

Total = 859,950 miles/year = 2356 miles/day

c) Calculate emission reductions achieved from the program.

Emission Reductions = VMT * Emission Factor

VOCs = 0.0014 kg/mile * 2356 mile/day = 3.3 kg/day
CO = 0.0114 kg/mile * 2356 mile/day = 27 kg/day
NOx = 0.002 kg/mile * 2356 mile/day = 5 kg/day

7. <u>Bus Bays on Oakland Park Boulevard</u>[16]

Broward County proposed to build 5 transit bus-bays along Oakland Park Boulevard between Andrews Avenue and Inverrary Boulevard. Currently there are three transit routes that provide service and make frequent stops along that segment of Oakland Park Blvd. The purpose of this analysis is to demonstrate that building bus bays will improve air quality by estimating the reduction in time loss due to buses stopping to load and unload passengers. The concept is based on the reductive effects of local transit buses on the traffic carrying capacity of an arterial street. The concept in Chapter 12 of the 1994 Highway Capacity Manual (HCM) was used to estimate that reduction. For comparison purposes, traffic carrying capacity of Oakland Park Blvd. was evaluated under two conditions: one with bus bays and the other without.

In the first case, (with bus bays), buses stop in a lane that is not used by moving traffic (curb parking lane), thereby reducing the impeding effects to other traffic. The time loss to other vehicles due to bus stopping at a bus bay is estimated at 4 seconds per bus which counts for bus acceleration and deceleration time in the traffic stream.

In the second case, buses stop in the normal traffic lane impeding traffic flow and causing queuing of vehicles behind the stopped bus. The time loss in this case includes the dwell time to load and unload passengers and time loss for stopping and starting. The time loss for the lane in which the bus operates can be estimated using equation 12-3 of the HCM.

TL = (g/c)*N*(D+L) where,

TL = time loss, in seconds per hour
g/c = intersection green time/cycle time ratio
N = number of buses that stop per hour
D = average dwell time, in seconds
L = additional time loss due to stopping, starting and queuing in seconds (6 to 8 seconds on average).

The analysis covers the impact of constructing five bus bays and to simplify the calculations, the reduction was estimated for one bus bay and then multiplied by five.

Assumptions

- Three bus routes operate along the subject segment of roadway
- 30 minute headway per route
- Number of buses (3*60/30) = 6 buses per hour
- Buses operate 16 hours/day average weekday
- The average speed along Oakland Park Blvd is 24.5 mph

Calculation of Loss Time with Bus Bays

The time loss is due to buses maneuvering in and out of bus bays.

Timeloss/hour = 4 seconds/bus * 6 buses/hour = 24 sec/hr

Where,

Time lost due to bus decel and accel out of bus bay, TL = 4
Number of buses per hour, N = 6
Average g/c = 0.4
Capacity of through lane = 1800 pcphpg (passenger cars per hour per green)
Capacity of one lane per hour at 0.4 g/c ratio = 1,800 * 0.4 = 720 pcphpg
Total green time available to through lanes is 0.4 * 3,600 sec/hour = 1,440 sec/hour

The percent loss in lane capacity may be expressed as:

(24 sec/hr / 1,440 sec/hour) * 100 = 1.7%

This results in a capacity loss in the right lane of 720 pcph * 0.017 = 12 pcph

Calculation of Loss Time without Bus Bays

The average dwell time using results from a field survey is 18 seconds per stop.

with,
g/c = 0.4
N = 6 buses/hr
D = 19 sec/bu
L = 6 sec/bus
TL = 0.4*6*(18+6) = 58 sec/hour

The percent loss in lane capacity is; (58/1,440)*100 = 4.03%

This results in a capacity loss in the right lane of 720 pcph * 0.0403 = 29 pcph

Emission Reduction Estimate

Net Capacity gain due to building Bus Bays = 29 - 12 = 17 pcph

The distance of the highway impacted by each bus bay is 500 feet

Net VMT gained by installing Bus Bays = (500 ft/ 5280 ft/mile) * (17 pcph * 16 hours/day)
= 26 mile/day

The average travel speed is 24.5 mph

VOCs = 26 mile/day * 2.31 g/mile * kg/1000g * 5 locations = 0.30 kg/day
CO = 26 mile/day * 20.31 g/mile * kg/1000g * 5 locations = 2.64 kg/day
NOx = 26 mile/day * 2.48 g/mile * kg/1000g * 5 locations = 0.32 kg/day

Vanpool Programs

1. General Analysis

Vanpools achieve emission benefits by reducing vehicle trips. Average commute distance is doubled to simulate a round trip. Average ridership should be based on historical vanpool size data obtained from the Metropolitan Planning Organization (MPO). The analysis is performed as follows:

a) Calculate vehicles removed by the vanpool.
VMT removed = Historical Vanpool Size / Avg. Vehicle Occupancy

b) Calculate the Daily Emission Reduction achieved by the reduced VMT, kg/day.
ER = VMT removed * Avg. Commute Length * 2 * Peak Hour Speed Emission Rate (LDGV) for Pollutant * kg/1000g

2. Dade County, Florida Vanpool Program[4]

The Dade County Vanpool Program provided 30 vans to qualified participants. Air quality benefits are achieved through the reduction in VMT associated with the reduction of individual commuters. The increase in vehicles due to the vans provides a somewhat negative offset of these benefits. The analysis consists of five steps.

1) Estimate the number of autos removed from the roadway by the vanpool program.
2) Calculate the Daily VMT eliminated.
3) Calculate the emission reductions due to the decrease in VMT.
4) Calculate the addition emissions generated by the new service.
5) Derive the Net Benefits from the Program.

The following provides an example.

a) Reduction in Automobile use is calculated by knowing the amount of seating and the average area auto occupancy. The total seating provided by the vanpool is 345 seats, divided into vans with capacities of 15 and 8 passengers. The average auto occupancy of Dade County is 1.22 persons per automobile. The calculation is as follows:
Autos Eliminated = Vanpool Seats / Auto Occupancy = 345 Seats / 1.22 Persons / Auto = 283 Autos

b) VMT reduction is calculated through the knowledge of average round trip commuter distance for Dade County.
VMT Reduction = Autos Eliminated * Average Commute Distance = 283 Autos * 21.8 Miles / Auto = 6169 Miles

c) Emission Reductions are found by using the appropriate emission rate for LDGVs.
The Average operating speed for Dade County is 27 mph.
Emission Reduction = Emission Rate * VMT * kg/1000g
Emission Reduction = 81.49 kg/day CO; = 10.49 kg/day VOC; = 10.12 kg/day NO_x

d) Emission increases, due to the implementation of the new vehicles, are calculated knowing the emission rate for Light Duty Gas Trucks (LDGTs) and the VMT for the fleet. The VMT is derived from the fleet size and the average Dade commute distance, previously noted, or 654 VMT.
Emission Reduction = Emission Rate * VMT * kg/1000g
Emission Reduction = 10.63 kg/day CO; = 1.33 kg/day VOC; = 1.22 kg/day NO_x

e) The Net Air Quality difference is thus a product of the Reductions calculated in step c) subtracted by the Increases in emissions calculated in step d).
CO = 70.86 kg/day
VOC = 9.16 kg/day
NO_x = 8.90 kg/day

Other Off-Model Methodologies

1. Incident Management[1]

The main goal of an Incident Management Program is to reduce congestion by removing vehicles which are debilitated, injured or just broke. Nonrecurring Congestion is the effect these vehicles have on the main line flow. Excess freeway emission are caused by this type of congestion. This analysis provides the basis for calculation of reduction of VOCs due to these programs; however, NO_x can be analyzed in a similar fashion.

a) Determine Regional Freeway VOC Emissions, E_B.

b) Determine Freeway Emissions due to Nonrecurring Congestion, E_C.
$E_C = E_B * 0.049$

Note: 4.9 Percent of Freeway Emissions are Caused by Nonrecurring Congestion.[5]

c) Next the Daily VOC reductions, E_D, are calculated. These assume, since freeway emissions are directly related to VMT, that the VMT in the program area is used to calculate emission reductions.
$E_D = L * VOL_i * E_C / VOL_T * EFF$

where,
L = Length of Freeway
VOL_i = Volume of Freeway i
VOL_T = Regional Freeway VMT
EFF = Project Effectiveness, 50% for Incident Detection and Response,
25% for Motorist Assistance, and 15% for Surveillance.

2. Pedestrian / Bikeway - General[1]

The main goal of bicycle and pedestrian facilities is to provide other transportation options for a community. The air quality benefits, as with most projects, come with a reduction in VMT. The general calculation for these projects is shown below.

a) First, calculate the Daily VMT reduction.
VMT Reduction = PD * Area * L * BMS

where,
PD = Population density of location, persons/mile^2
Area = Project length * 1 mile radius, mile^2
L = Round trip length, one-half of the project length times 2 daily trips, miles
BMS = Bike mode share, %

b) Last, calculate the Daily Emission reductions for a pollutant.
$E_D = EF_x$ * VMT Reduction

where,
E_D = Daily Emissions, grams/day
EF_x = Emission factor for pollutant x, grams/mile
VMT = vehicle mile/day

3. Bikeways - General

Little data is available on the utilization of bikeways; however, if such data is available it can prove invaluable in providing mode shift data to predict VMT reduction. The following is an analysis which shows how to calculate emission reductions if a history of mode shift percentage is known.

a) First Calculate daily VMT reduction provided by mode shift in the corridor.
VMT Reduction = AADT in the corridor * PMS

where,
PMS = historical percentage of mode shift for area

b) Last, calculate the Daily Emission reductions for a pollutant.
$E_D = EF_x$ * VMT Reduction

where,
E_D = Daily Emissions, grams/day
EF_x = Emission factor for pollutant x, grams/mile
VMT = vehicle mile/day

4. Sidewalks Near Schools in Farragut, Tennessee[6]

This project connected and extended previously constructed sidewalks along the parental responsibility zone of the Farragut schools. This analysis assumes a minimum usage increase of 10%, with a VMT reduction of 2 miles on arterials and 5 miles on local roads. There are 5,602 students in Farragut schools. It should be noted that students walking remove 4 vehicle trips. The analysis is as follows:

a) Since VMT is reduced on both arterials and local roads, there are two VMT reduction calculations.
Students with Travel Mode Change = 5602 *.10 = 560
VMT Reduction (Arterials) = 560 Persons * 2 Miles / Person = 1120
VMT Reduction (Local) = 560 Persons * 5 Miles / Person = 2800

b) Knowing the Average Speed for the given roadway classification emission factors are generated for both VOC and NO_x by roadway classification.
VOC Reduction = (1120 VMT * .00194 kg/mile) + (2800 VMT * .00227 kg/mile) = 8.6 kg/day

NO_x Reduction = (1120 VMT * .0022 kg/mile) + (2800 VMT * .0019 kg/mile) = 7.8 kg/day

5. I/M Compliance Changes, Texas[1]

Procedures leading to a higher compliance rate for a I/M program benefit air quality by detecting then repairing faulty emission control systems. The Texas Air Control Board was asked to supply projected compliance rates for changes to our current I/M system. Current compliance rates for each county are available from TACB. Emission benefits are calculated with the following equations:

a) The first step is to calculate the emission rates before and after a change in compliance rates, g/day.
Improved Emissions = Projected I/M compliance * AADT * 24hr Avg. Speed Emissions
Previous Emissions = Current I/M compliance * AADT * 24hr Avg. Speed Emissions

b) The final step is to calculate the Daily Emission benefit due to the increased compliance rate, kg/day.
Daily Reductions = (Improved Emissions - Previous Emissions) * kg/1000g

6. Travel Demand Management (TDM), Public Education Campaign, Pinellas County, Florida[7]

The purpose of this project was to provide intermodal transportation information via several programs within a public education campaign to promote a shift from the use of single occupant vehicles (SOV) to alternatives such as bicycle, public transportation, and ridesharing. By educating the public to these transportation options and their cost effectiveness, a substantial number of vehicles could be eliminated from the roadway, thus reducing VMT.

a) The first step in the analysis is to combine the knowledge of Work Trips for the area with the Trip Rate. Pinellas County has an estimated employment of 377,312. Knowing the Home Based Work Trip Rate is 1.8, provided by the FSUTMS model, Daily work trips can be calculated.

Daily Work Trips = Total Employment * Trip Rate = 377,312 * 1.8 = 679,162 Trips

b) The 1991 Tampa Bay Regional Survey conducted by Florida Department of Transportation provided Trip Length Distribution information. This survey showed the Mean Trip Length was 26.6 minutes, reflecting travel time and terminal times. Using an average area speed of 19.6 mph the Average Trip Length can be calculated.

Average Trip Length = Average Travel Speed * Mean Trip Length * hr / 60min = 19.6 miles/hr * 26.6 min * hr / 60min = 8.68 miles

c) Next the VMT reduction can be found with the knowledge of the Daily Work Trips and Average Trip Length.

Work VMT Reduced = 679,162 * 8.68 miles = 5,895,123

d) Based on a study conducted by STAPPA/ALAPCO an estimated percent reduction in work travel VMT was found to be 0.5 %.[8] Therefore, the VMT Reduction due to the implementation of the Public Education Campaign is:

VMT Reduction = 5,895,123 * 0.5 = 29,476

e) The final step is to calculate the emission reductions using MOBILE emission factors for the known Average Speed of 19.6 mph.

Emission Reduction = VMT * Emission Factor (g/mile) * kg/1000g
VOC Reduction = 29,476 * 2.36 g/mile * kg/1000g = 69.6 kg/day
NO_x Reduction = 29,476 * 2.46 g/mile * kg/1000g = 72.5 kg/day
CO Reduction = 29,476 * 20.38 g/mile * kg/1000g = 600.7 kg/day

7. Ramp Metering[9]

Project/Policy Description

Ramp metering is a common form of urban traffic control. It aims to reduce or eliminate operational problems resulting from freeway congestion by restricting flow to the freeway mainline. With mainline demand restricted to less than the available capacity, ramp metering tends to maintain uninterrupted, non-congested flow on the freeway. By smoothing vehicle flow, ramp metering aids in utilizing the existing freeway capacity and also reduces the probability of accidents at merge locations.

The total change in vehicle emissions due to ramp metering can be broken down into 3 elements: travel changes on the mainline, travel changes on the arterial street system, and changes in operating conditions on the ramp. All three elements are affected by the changes in traffic volumes resulting from ramp metering, including increased traffic volumes on the arterial street system. Emissions on the ramp change because of the changes in the way the ramp is operating. Ramp metering results in greater vehicle idling and greater acceleration on the ramp then is experienced without ramp metering. The travel demand forecasting model accounts for emissions resulting before the implementation of ramp metering. Therefore, the change in emissions before and after ramp metering is calculated in this analysis so that the difference can be applied to the total regional emissions from the travel demand forecasting model.

Assumptions

1) Vehicles entering at on-ramps are not experiencing delay before the implementation of ramp metering.
2) Emissions associated with the change in acceleration/deceleration on the ramps are negligible compared to emissions resulting from the increases in travel speeds on the freeway mainline.
3) Ramps are only metered until the maximum storage capacity of the ramp is met. After that time, ramp metering is turned off.
4) Queuing emissions on the ramp include that emission of the vehicle traveling on the ramp at low speeds.
5) No consideration was given to concurrent use of HOV facilities in the ramp metering corridor.

Emissions Analysis

a) Determine the freeway limits and time period for the ramp metering. Considerations for the implementing ramp metering are discussed in the *Manual on Uniform Traffic Control Devices* and the NCHRP Report 232, *Guidelines for Selection of Ramp Control Systems,* Page 52. The Florida DOT used freeway volume after the merge point and speed to determine if ramp metering was warranted as documented in the *Southeast Florida Intelligent Corridor System Ramp Metering Analysis.*

b) Obtain volumes (HPMS adjusted), capacities, and speeds of travel demand network links for all freeways, ramps, arterial cross streets and parallel cross streets which will be affected by ramp metering.

c) Calculate total emissions before ramp metering for the time period when ramp metering will be implemented (such as the peak period):

Total Emissions = 3 ($LENGTH_i$ x $\#VEHICLES_i$ x EMISSIONS $RATE_i$)

where,
$i = 1$ to n, and n is the number of links

d) Determine ramps to be metered and their associated storage capacity and metering rates. Ramp metering rates can be determined by first calculating the reduction in demand required to result in the desired mainline operating condition. After the mainline difference is calculated, the difference is distributed between the upstream ramps. The metering rate will be dependent on the required reduction, the demand at the particular on-ramp and the storage capacity of the ramp.
The recommended minimum metering rate is 300 vehicle per hour (for a one-lane ramp), and the recommended maximum is 900 vehicles per hour (for a one lane ramp).[10]

e) Calculate total ramp delay and the maximum individual waiting time due to the implementation of ramp metering. These can be calculated using basic queuing diagrams of number of vehicle accumulated over time (see example in Figure 1).

f) Estimate the diversion of vehicles to the parallel arterial. The number of vehicles diverting will be a function of trip length, queue length, ramp delay, and the availability and efficiency of alternate routes.[11]

g)Adjust volume/capacity ratios for all links as needed to account for ramp metering (queuing on the ramp) and diversion.

h) Calculate new freeway, cross street arterial and parallel arterial speeds using the travel demand model volume/delay curves.

i) Calculate after metering emissions based on new link volumes, capacities and speeds. Freeway and arterial link emissions can be calculated as described in step 3.

j) For the on-ramps, calculate queuing emissions as follows:
Total Emissions = Total Delay x Emissions $\text{Rate}_{\text{Idling}}$

k) Calculate the difference between before metering and after metering emissions.

l) Calculate emission differences for all peak periods which are metered.

m) Apply the total difference in emissions for all peak periods to the total emissions calculated from the travel demand model output (total emissions before metering).

Caveats

1) The congestion mitigation benefits of ramp metering are conservative since the methodology is based on average annual daily traffic and no incident delay is incorporated into the analysis. Ramp metering will reduce incidents at the freeway merge and the associated vehicle delay.

2) The emissions estimate assumes that there will be no change in demand as a result of the ramp metering. The same number of vehicle trips will be made although they may be diverted to the arterial street systems. The methodology does not take into consideration latent demand that may be generated with better operations on the freeway; in the forecast years, this will be less critical due to the fact that demand will probably greatly exceed capacity.

8. University North Commuter Center[13]

The University North Commuter Center will offer information and related services to promote greater use of a range of commuter alternatives to SOV travel, including public transit, ridesharing, bicycling, walking, telecommuting and others. Services include a staffed information center, located at the University Mall, a transportable kiosk for special events within University North, a "Virtual Commuter Center" web page, and covered bicycle storage units available to participating employment sites. The analysis is as follows:

a) Estimate the number of users/participants, users. 400 new users.

b) Estimate gross vehicle trip reduction (VTR) based on mode shifts. Gross one-way vehicle trips reduced = users * mode Trip Reduction Factor (TRF).

	Users	TRF	Daily Trips	Gross Trips Reduced
New Carpooler	210	0.5	2	210
New Vanpooler	10	0.9	2	18
New Transit User	100	1	2	200
New Bicyclist	50	1	2	100
New Walker	20	1	2	40
New Telecommuter	10	1	2	20
New Compressed Work Week	0	1	2	0
New Satellite Work Center User	0	0	2	0

Total Gross Trips Reduced = 588

c) Fraction of users or participants using prior HOV and/or SOV access, in percent.

HOV% = 10.0

d) Determine net VTR. Net Vehicle One-way trips reduced = Gross VTR * (1 - HOV%/100)

Net VTR = 588 * (1 - 10/100) = 529.2

e) Determine vehicle miles of travel reducted (VMT). Average one way trip length = 11 miles/trip.

Reduced VMT = Net VTR * Average Trip Length = 529.2 * 11 = 5821.2

f) Determine daily emissions reduced. Daily Emissions Reduced = Emission Factor * Reduced VMT
CO Reduced = 5821.2 mile/day * 0.0114 kg/mile = 66.4 kg/day
NOx Reduced = 5821.2 mile/day * 0.0020 kg/mile = 11.6 kg/day
VOC Reduced = 5821.2 mile/day * 0.0014 kg/mile = 8.1 kg/day

9. Qualitative Analysis - Intermodal Transit Links[12]

Project Description

The study will examine transit system connections withing the Downtown and a Historic Area that will coordinate with other transportation components such as parking and bicycle / pedestrian facilities.

Purpose

The proposed CMAQ grant will fund a study which examines opportunities to improve the efficiency of transportation services in the Downtown and a Historic area. This project will examine optimal transfer of locations for intermodal connections between all modes of transportation including an electric streetcar, future rail transit, buses, bicyclists, pedestrians, and automobiles. Parking availability and opportunities will also be analyzed.

Project Justification

Effective intermodal connections are essential to an efficient transportation system. This study will identify optimum locations for intermodal transfers to reduce vehicular congestion, idle times in buses and automobiles, and overlapping transit service. In addition this analysis will identify ways to improve service and public use for through trips and intermodal connections by improving or streamlining routes and improving and adjusting headways. The air quality benefits derived from this project are difficult to quantify. However, for the purposes of this analysis, it is assumed that efficient intermodal connections will achieve a substantial reduction in the overall mobile source emissions in the study area for several reasons.

C Increased transit ridership attributed to better connectivity
C Amenities for pedestrians and cyclists (information kiosks, bike racks, shelters)
C Increased use of non-motorized travel
C Less vehicle idle times waiting for connections
C Reduced, shorter internal trips, less cold starts

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